

PARTIAL REPLACEMENT OF FINE AGGREGATE WITH WASTE GLASS POWDER AND COARSE AGGREGATE WITH WASTE PLASTICS IN CONCRETE MIXTURES

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ABSTRACT

The question of whether constructions can be done in a more sustainable way is becoming pertinent because of the depletion of natural resources and rising environmental issues. This study assesses the possibility of having waste glass powder as a partial substitute for fine aggregate and waste plastics as a substitute coarse aggregate in concrete mixes. The experimental study measures different mechanical properties, which include compressive, flexural, and tensile strengths. The findings suggest that the optimal replacement of 30% glass powder and 10% plastic not only benefits concrete performance, but also lessens environmental impact. This report presents a cultivar of sustainability with concrete and environmental benefits.

Keywords: Sustainable concrete, waste materials, glass powder, recycled plastics, compressive strength.

1. Introduction

The creation of traditional concrete makes use of limited resources which causes harm to the environment. The issue of sustainability is helped by the replacement of certain waste products such as glass powder and plastics as partial substitutes for aggregates. When added to concrete, glass powder increases its strength considerably while recycled plastics lessens the requirement of natural aggregates. This paper assesses the environmental and mechanical performance of concrete that uses these substitutes.

2. Literature Review

2.1 Waste Plastics as Aggregate Replacements

Numerous studies have explored the use of plastic waste in concrete applications. Chong et al. (2023) demonstrated that incorporating PET as up to 30% of coarse aggregates reduces strength loss while promoting sustainability. S. Vanitha et al. (2023) established that substituting 4% and 2% of plastic waste for coarse aggregates in M20 concrete pavers and solid blocks, respectively, resulted in significant property enhancements. Furthermore, Rahantha Rakshan et al. (2023) addressed concerns related to gas emissions during the processing of PET, HDPE,



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and PP, advocating for heating in an oxygen-free environment. Additionally, Noor Azline M. N. et al. (2023) indicated that using PVC plastic coarse aggregates in proportions below 30% leads to improved mechanical properties.

2.2 Glass Powder as Fine Aggregate Replacement

Dhanabal P. And Sushmitha K.P. (2022) analyzed the replacement of cement and fine aggregate with glass powder and found that the optimum performance was achieved with 30% replacement. Jawad Ahmad et al. (2022) noted the strength development of glass powder due to pozzolanic reactions was more beneficial in the long term. M. Selvakumar et al. (2021) reported that the addition of basalt fiber to glass powder improved the mechanical properties even further. S. Arivalagan and V. S. Sethuraman (2020) reported that the replacement of up to 30% of fine aggregates with glass powder boosted the compressive, tensile and flexural strengths by 20%.

2.3 Research Gaps

Although previous studies have proven the feasibility of using glass powder and plastics in concrete, limited studies have addressed combined effects. Also, the durability of glass powder and plastics-modified concrete and environmental considerations under real-world situations were neglected. The present study tackles these gaps by assessing mechanical properties and related sustainability aspects.

3. Materials and Methods

3.1 Material Collection and Preparation

- **Glass Powder:** Procured from Swisston Industry, KINFRA Park, Thiruvananthapuram. The annual production of around 200 million tons of non-recyclable glass waste highlights the urgent need for its reuse.
- **Waste Plastics:** Low-density plastics from packaging were utilized as replacements for coarse aggregates at levels of 5%, 10%, 15%, and 20%.
- **Cement:** 53-grade Ordinary Portland Cement (OPC) was selected for its high strength and cost-effectiveness.
- **Fine Aggregate:** Manufactured sand (M-sand) was used after sieving and washing, following IS 2386 standards.

- **Coarse Aggregate:** Crushed stone aggregates were used, tested for gradation and specific gravity.

3.2 Mix Design

Concrete mixtures were prepared with different levels of glass powder replacement (10%-30%) and plastics (5%-20%) in order to carry out mechanical tests for workability, compressive strength, tensile strength, and flexural strength.

4. Results and Discussion

4.1 Workability

The increase in plastic content resulted in lower slump values, which suggests a decrease in workability. At lower replacement levels, glass powder had little effect, but workability decreased significantly when the replacement exceeded 30%.

4.2 Compressive Strength

The maximum compressive strength recorded was 24.8 MPa with a 30% replacement of glass powder. Additionally, a 10% replacement with plastic aggregate resulted in an optimal compressive strength of 18.88 MPa.

4.3 Split Tensile Strength

The highest tensile strength was found with a combination of 30% glass powder and 10% plastic replacement..

4.4 Flexural Strength

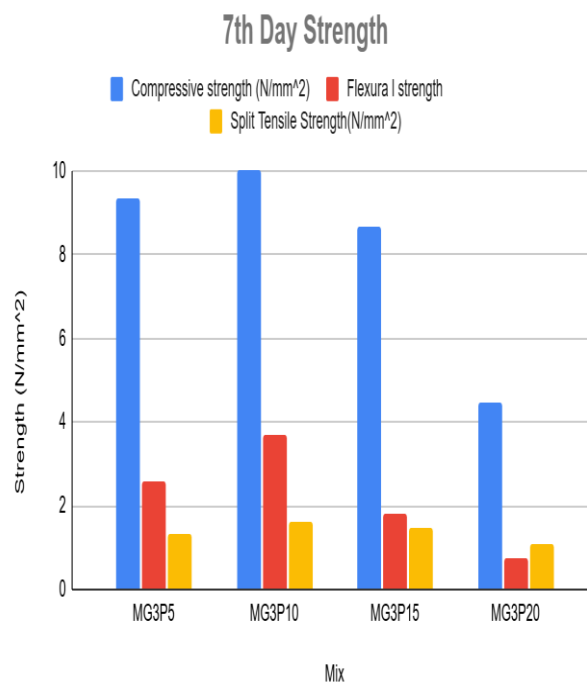
The trends in flexural strength were similar to those observed in tensile strength, showing maximum values at 30% glass powder and 10% plastic replacement.

4.5 Environmental Impact

Diverting waste glass and plastics from landfills helps to minimize environmental harm. Decreasing our dependence on natural aggregates helps to preserve limited resources.

Table 4.1: Results For Tests done after replacing plastic in various percentages.

Mix	% of plastic	7 th day strength			28 th day strength		
		Compressive strength (N/mm ²)	Flexura l strength (N/mm ²)	Split Tensile Strength(N /mm ²)	Compressive Strength(N/mm ²)	Flexura l strength (N/mm ²)	Split Tensile Strength(N/m m ²)
MG3P5	5	9.33	2.583	1.34	14.44	3.69	1.69
MG3P10	10	10	3.69	1.62	18.88	5.535	2.56
MG3P15	15	8.66	1.805	1.48	12.22	2.58	1.41
MG3P20	20	4.44	0.738	1.06	7.77	1.845	1.27



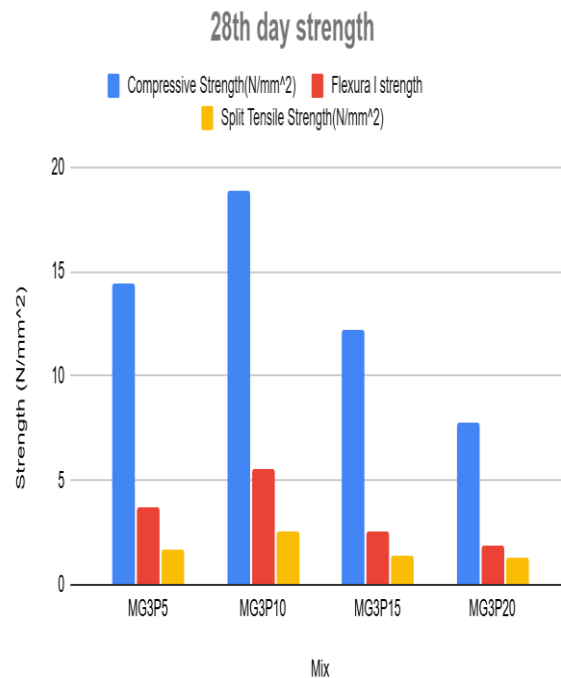


Fig 4.1: Bar Graph of 7th & 28th Day Test

5. Conclusion

A partial replacement of aggregates with 30% glass powder and 10% plastic wastes results in enhanced mechanical properties of concrete and sustainability. The present study brings forth the prospects of integrating waste management into construction practice. Future research may consider long-term durability, environmental impact assessment, and feasibility for large-scale application.

Conflict of Interest Statement

The authors declare no conflicts of interest regarding this research.

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